Preprint
UCRL-JC-147519

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This article was submitted to
American Society of Civil Engineers 2002 Water Resources Planning and Management Conference, Roanoke, Virginia, May 19-22, 2002

March 5, 2002

U.S. Department of Energy

Lawrence
Livermore
National
Laboratory

Managing Floods and Resources at the Arroyo Las Positas

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Abstract

Engineers and water resource professionals are challenged with protecting facilities from flood events within environmental resource protection, regulatory, and economic constraints. One case in point is the Arroyo Las Positas (ALP), an intermittent stream that traverses the Lawrence Livermore National Laboratory (LLNL) in Livermore, California. Increased runoff from post-draught rainfall, upstream development, and new perennial discharges from LLNL activities have resulted in increased dry weather flows and wetland vegetation. These new conditions have recently begun to provide improved habitat for the federally threatened California red-legged frog (*Rana aurora draytonii*; CRLF), but the additional vegetation diminishes the channel's drainage capacity and increases flood risk. When LLNL proposed to re-grade the channel to re-establish the 100-year flood capacity, traditional dredging practices were no longer being advocated by environmental regulatory agencies. LLNL therefore designed a desilting maintenance plan to protect LLNL facility areas from flooding, while minimizing impacts to wetland resources and habitat. The result was a combination of structural upland improvements and the ALP Five Year Maintenance Plan (Maintenance Plan), which includes phased desilting in segments so that the entire ALP is desilted after five years. A unique feature of the Maintenance Plan is the variable length of the segments designed to minimize LLNL's impact on CRLF movement. State and federal permits also added monitoring requirements and additional constraints on desilting activities. Two years into the Maintenance Plan, LLNL is examining the lessons learned on the cost-effectiveness of these maintenance measures and restrictions and re-evaluating the direction of future maintenance activities.

Introduction

The main site of Lawrence Livermore National Laboratory (LLNL) is approximately 3.28 square kilometers (one square mile); it is populated by more than 8,000 LLNL employees, contractors, students, and visitors. Approximately 80 to 90 percent of the site surface drainage eventually discharges to the Arroyo Las Positas (ALP). LLNL must (1) transport water in the ALP effectively, safely, and efficiently through the site, and (2) protect water quality and habitat in the ALP. When LLNL proposed to re-grade the channel to re-establish the 100-year flood capacity, state and federal agencies applied restrictions on LLNL's maintenance activities through permits.

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The ALP includes approximately 8600 square meters (2.1 acres) of jurisdictional waters of the United States and is home to a small but viable population of the federally threatened California red-legged frog (*Rana aurora draytonii*; CRLF). During most years, state-protected raptors, white-tailed kites (*Elanus lecurus*), have also been found to nest in the trees along the ALP. Consequently, LLNL is subject to Waste Discharge Requirements (WDR) administered by the State of California's water quality protection agency (Water Board), a Streambed Alteration Agreement (SBAA) by the California Department of Fish and Game,[4] Nationwide Permits (NWP) by the U.S. Army Corps of Engineers (ACOE), and a Biological Opinion issued by the U.S. Fish and Wildlife Service (USFWS). These requirements have been the primary drivers that have shaped how LLNL conducts its channel maintenance activities.

This paper first provides a brief overview of the current ALP maintenance activities and monitoring and mitigation requirements in LLNL's various regulatory permits. The discussion then describes LLNL's experiences over the last two years of implementation and some of the resource monitoring information that has been collected. Lastly, this paper examines whether the objectives of the maintenance activities are being met.

Regaining Channel Capacity While Minimizing Impacts to Resources

The objectives of LLNL's channel maintenance activities include:

- Providing adequate flood control capacity while minimizing maintenance requirements.
- Minimizing and mitigating permanent negative impacts to habitat.

To achieve these objectives, LLNL has constructed structural upland improvements immediately adjacent to one side of the ALP (e.g., earthen berm and/or retaining wall) and is implementing the ALP Five Year Maintenance Plan (Maintenance Plan) described below.

Sediment Removal. LLNL's Maintenance Plan consists primarily of ongoing sediment removal, which includes phased desilting of the entire 2100-meter (7000-feet) reach of the ALP onsite over a five-year period. Each year 20 percent (approximately 420 meters; 1400 feet) of the ALP is desilted to maintain channel capacity for a 10-year flood event.

Notable about the LLNL Maintenance Plan is its unique phased-segment approach. To avoid disturbing large continuous stretches of the ALP and its habitat features, the 20 percent to be desilted each year is further divided into segments. Where CRLF were present and where valuable habitat existed during 1997 surveys, the length of each segment is approximately 30.5 meters (100 feet); elsewhere, the segments are approximately 91.5 meters (300 feet). Figure 1 illustrates the segments of the ALP.

The removal activities may also include excavation and minor grading to re-establish flow lines. Sediment removal and other site disturbing activities are performed in late summer when the channel is driest, for ease of operation, to minimize erosion potential, to avoid affecting water quality, and to avoid impacts to CRLF, if present. Additional constraints on the desilting activities include the following.

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[4] Subsequent to the issuance of the SBAA, CDFG Legal Council determined that LLNL is not subject to SBAA requirements. However, LLNL and CDFG are developing a Memorandum of Understanding regarding LLNL activties that affect streambeds to ensure ongoing protection of resources.

No working of adjacent segments during two consecutive years. This is to further ensure that desilting activities do not disturb large continuous stretches of the ALP, potentially hindering CRLF movement. This also encourages vegetation re-growth in the desilted areas.

No equipment allowed in the channel. Desilting is conducted by an excavator located on the side bank.

No standing water allowed in the active desilting site. LLNL diverts water around the work zones by constructing cofferdams and dewatering the work zone. A pipe that is allowed to discharge downstream of the work zone diverts water accumulating behind the cofferdam. Water removed from the work zone is pumped onto a pervious surface above the bank and away from the channel so that no water from this dewatering is allowed to discharge back to the ALP because of the potential for high sediment concentrations.

Effluent concentration limitations on ALP flows downstream of the active sites. LLNL must implement a water quality self-monitoring program that is described in further detail below.

Vegetation Removal. Annual channel maintenance activities also include ongoing vegetation removal to maintain unimpeded flow and channel capacity, with emphasis on managing woody trees and shrubs. Routine maintenance includes mowing the grass on the side slopes, trimming the cattails (*Typha spp.*) to a height of four feet, and removing or cutting woody vegetation. Hand tools, such as chain saws and weed whackers, may also be used within the channel. Mowing is performed in June, which is the end of the growing season and when most annual vegetation has completed the growing cycle. Storm debris is also removed as needed to maintain flow capacity.

Bed and Bank Stabilization. LLNL minimizes erosion with preventive and corrective measures. Severely eroded areas in the channel bed are reconfigured to the design elevation through the use of a series of check dams. The check dams collect sediment in steps and bring the channel back to the design elevation over time, while also providing a variety of habitat features and structures. Geotextiles and erosion control fabrics are also used where further stabilization is warranted. Biotechnical techniques, including seeding of herbaceous material such as grasses, are used to anchor the soil. The bed and bank of the newly desilted areas are protected with biodegradable erosion control blankets. Riprap underlain by a geotextile is placed in the channel to provide velocity dissipation in transition zones. These transition zones are located between existing grades and the grades in newly desilted areas, and between existing outfalls into or existing hard structures within the newly desilted areas. Banks can be stabilized, as needed, with common techniques such as placement of wire and rock gabions, erosion control fabrics, or rip-rap.

Sediment Control During Site-Disturbing Activities. LLNL controls sediment during desilting by prohibiting heavy equipment within the channel, immediately transporting spoils material away from the project site or to protected areas to dry spoils before transport, using cofferdams to isolate work areas as necessary, and avoiding work during the wet season. Water removed from within the active work area is pumped to an upland area rather than downstream.

Maintaining Aquatic Habitat Value. LLNL's wildlife biologist performs surveys for the presence of special-status species before any site-disturbing activities are allowed to begin. Prior to the start of work each day, LLNL's biologist searches for and collects CRLF in the planned

work zones. The collected CRLF are translocated to the next available suitable habitat above or below the work zone. The wildlife biologist must be present to monitor any site-disturbing activities that involve sediment or vegetation removal. Furthermore, all LLNL staff associated with ALP maintenance activities receive training to identify the four different types of amphibians on site. This further increases projects staff's awareness of and involvement in CRLF conservation at LLNL.

Monitoring and Mitigation Requirements

Two of LLNL's permits to conduct ALP maintenance activities require some form of monitoring and/or mitigation activities. In addition to the standard observation/inspection requirements, LLNL's WDR requires water quality monitoring, applies effluent concentration limitations on downstream discharges, and requires resource (CRLF, aquatic macro-invertebrate, and vegetation re-establishment) monitoring. The WDR and ACOE NWP also include mitigation requirements that are further described below.

Water Quality Monitoring. LLNL is required to collect at least two receiving water grab samples at active desilting sites every 24-hour period, evenly spaced during the work hours. The first set of samples can be collected no earlier than 1 hour after desilting starts for the day on days when water is present in the channel or there is a discharge of diverted flow. Receiving water sample results are then compared with background samples.

LLNL obtains background water samples prior to desilting activities. Background grab samples are collected 15 meters (50 feet) below the downstream discharge point of the diverted water. Alternatively, samples collected on a daily basis a minimum of 152 meters (500 feet) upstream of the desilting site can be used for background samples for discharges occurring on the same day.

All grab samples are analyzed for dissolved oxygen (DO), pH, and turbidity. Receiving water limitations are exceeded when:

- The receiving water DO concentration is below 5.0 mg/L or the background DO concentration, whichever is lower.
- The receiving water pH differs by more than 0.5 pH units from the background pH.
- The receiving water turbidity is more than 50 nephelometry turbidity units (NTU) and the receiving water turbidity concentration has a 10 percent incremental increase from the background turbidity concentration.

When receiving water limitations are exceeded, LLNL must conduct confirmatory sampling and every subsequent 2 hours until the exceedance has been corrected. If the exceedance continues for a 12-hour period, LLNL must notify the Water Board and provide corrective measures. A violation of the WDR occurs if the exceedance continues for a 24-hour period, and desilting activities must stop until the cause of the violation is found and sampling demonstrates that the exceedance has been corrected. Alternatively, desilting can resume when LLNL provides a corrective action plan acceptable to the Water Board.

Resource Monitoring. Annually, LLNL collects information on adult CRLF breeding presence (distribution) and activity levels during the breeding period (generally March). Specifically, LLNL compares CRLF breeding sites and their spatial relationship to the most recently maintained areas of the ALP.

LLNL also collects aquatic macro-invertebrate species presence data through D-frame dip-net point sampling in each of the Segment 3 designated areas (see Figure 1). The dip-net samples are collected no more than 30 days prior to when desilting activities begin, and between 30 to 60 days after desilting activities end. LLNL conducts additional macro-invertebrate sampling in late spring as a control sample. The control location is a zone that is not disturbed until the fifth year of the maintenance plan.

Lastly, LLNL monitors the re-establishment of wetland vegetation in each of the Segment 3 designated areas (see Figure 1). LLNL staff take photographs of these zones prior to and after the initial maintenance activity, and each subsequent spring from the same vantage point.

Mitigation Requirements. The USFWS Biological Opinion required LLNL to pay $170,000 to the USFWS, which has been deposited into an endowment held by the Center for Natural Lands Management to be used for the purchase and management of CRLF habitat within 15 miles of LLNL. The Water Board's WDR also required LLNL to develop a long-range management plan for Arroyo Seco, another Water of the U.S. on site that receives the other 10 to 20 percent of LLNL's surface runoff. LLNL's other mitigation requirement came from the ACOE when LLNL applied for authorization to install the check dams. ACOE requires LLNL to remove exotic vegetation to allow for the re-establishment of native wetland species. To fulfill this requirement, LLNL has proposed the planting plan/seed mix of native plants described in Table 1. The seed mix includes nutsedges (*Cyperus spp.*) that LLNL staff have observed during field surveys to be supportive of CRLF egg mass oviposition sites (breeding sites).

Implementing the ALP Maintenance Plan

All required authorizations were completed in time for desilting to begin in calendar year 2000. In August and September 2000, LLNL removed vegetation in Sections 3G, 3F, 3E, 3D, 3C, 1D, 2A, 1C, and 3B. Check dams were installed in Sections 3G and 3F, and riprap was installed in Section 3E. LLNL received regulatory approval to desilt Sections 1D, 2A, and 1C in place of Section 3A, which could not be desilted at the time because initial surveys identified CRLF larvae (tadpoles) in Section 3A. Section 3H was not desilted because of budget constraints. The budget over runs resulted primarily from the cost of staging multiple desilting sites. Specifically, additional costs were incurred because of (1) taking down and re-installing security fences to allow access for the excavator, which must stay on top of the bank; (2) moving the heavy equipment between work zones; (3) contractor difficulties with working in an aquatic environment; and (4) scheduling delays that required contracting a second biologist so that two zones could be desilted concurrently and all desilting could be completed by October 1 as required by LLNL's permits. Because of cost and safety issues, vegetation removal using hand tools was abandoned altogether.

During 2000 channel maintenance activities, turbidity, and pH receiving water results for Section 3E exceeded the allowable incremental difference as shown in Table 2. The exceedances in Section 3E were found to have resulted from dewatering activities where the water was pumped out of the work zone and discharged downstream. The exceedances were corrected when the pumped water was discharged onto the top of the bank of the ALP in a manner that prevented the water from flowing back into the channel. All other monitoring

showed that water diversion discharges during desilting activities met receiving water limitations.

During calendar year 2001, channel maintenance activities included only Sections 3H, 2H, and 5H. LLNL also removed vegetation in concreted portions of the channel (Area 19 and the ALP influent) shown in Figure 1. The scheduled 20 percent of the channel could not be desilted because of insufficient funding. In 2001, LLNL used a water bladder for a cofferdam at Section 3H. The water bladder is basically a large rubber sack filled with water that spanned the width of the ALP and was about 0.9 to 1.2 meters (3 to 4 feet) high. LLNL used the water bladder at the advice of ACOE staff because it did not require a permit from the ACOE. However, it was difficult to adequately seal the water bladder to the channel bottom; the result was a continuous leak that required continual dewatering of the work zone. For 2002, LLNL has chosen to apply for NWP 33 so that sand bags can be used for the cofferdams. All monitoring in 2001 showed that water diversion discharges met receiving water limitations.[5]

Results of the Resource Monitoring

In March 2001, LLNL staff found that CRLF were not present or breeding in ALP zones desilted in 2000. Conversely, Pacific tree frogs (*Hyla regilla*), which tend to be more opportunistic and may have less defined micro-habitat requirements, were present and breeding in seemingly normal densities within 2000 maintenance zones. As previously mentioned, CRLF appeared to favor nutsedges for egg mass oviposition sites; during these surveys, the nutsedges had not re-established yet in the desilted zones.

CRLF surveys were completed during optimal ambient conditions (nocturnal, warm, no wind). Even so, CRLF are extremely difficult to detect, given their secretive nature, cryptic coloration (camouflage), and ability to hide quickly in water or vegetative cover. Prior to the start of maintenance activities, 10 CRLF (9 in 2000 and 1 in 2001) were captured and translocated out of the maintenance zone. But once desilting activities started, 113 CRLF (63 in 2000 and 50 in 2001) were safely captured and translocated to the next available habitat. Each year, one CRLF mortality occurred during desilting activities, although the mortality in 2001 was never confirmed. Field survey results suggest that CRLF return to desilted zones after the following spring and summer when vegetative cover begins to re-establish within the wet zones. CRLF were observed in the 2000 maintenance zones with perennial water by the 2001 pre-activity surveys. Desilted zones that remain dry during most of the year have had no observable CRLF activity.

To date, 20 aquatic macro-invertebrate families have been identified in the ALP. In 2000, 14 aquatic macro-invertebrate families were identified prior to maintenance activities in the three maintenance zones sampled. Within 60 days of completing the 2000 maintenance, aquatic invertebrates were re-sampled, and 11 families were identified. In 2001, three zones desilted in 2000 were again sampled, and 14 aquatic invertebrate families were identified. In control samples taken prior to maintenance activities, 10 aquatic invertebrate families were identified; 60 days after completion, 9 aquatic invertebrate families were identified. In 2001, the control sites had 8 aquatic macro-invertebrate families. Qualitative species richness data suggest that pre- and post-maintenance zones have similar species composition.

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[5] 2001 monitoring results will be published in LLNL's annual site environmental report, due to be released in September 2002.

Pre- and post-maintenance activity photographs were taken of all the Segment 3 designated areas that have been desilted. Species richness across the zones appears to have increased post-maintenance activities, primarily because of the removal of dense stands of cattails that out-compete other species. In zones that do not receive dry weather flows, vegetative diversity is dominated by non-native annual grasses, which are often the first to colonize recently disturbed sites.

Meeting the Maintenance Plan's Objectives

Did the Maintenance Plan provide adequate flood control capacity while minimizing maintenance requirements? Overall, whether the Maintenance Plan has been successful in meeting this objective is difficult to evaluate; two years into the plan, there have been no significant storm events that test fully the flood control capacity of the channel. Furthermore, recent budget constraints have prevented LLNL from desilting 20 percent of the ALP in 2001 and again in 2002, to maintain channel capacity for a 10-year flood event. LLNL estimates that the cost of the phased-segment approach in 2000 was 50 percent higher than cost estimates to desilt a continuous 20 percent reach of the ALP. However, the potential cost savings for desilting a continuous 20 percent reach of the ALP must be weighed against the potential cost of re-opening LLNL's permits. On a smaller scale however, some successful elements of the Maintenance Plan have been notable. For example, the rock check dams have been successful in re-establishing the design elevation in severely eroded areas. And rip-rap underlain with a geotextile has been successful in providing velocity dissipation in transition zones. It has also been very important to maintain a segment map that allows for changes caused by CRLF movement. Because the 100- and 300-foot segments are based on 1999 surveys, the intent of the segmentation is no longer being met as different sections of the ALP are desilted, and the areas of desirable habitat have changed.

Did the Maintenance Plan's unique phased-segment approach minimize permanent negative impacts to habitat? As with the Maintenance Plan's objective to provide adequate flood control capacity, it is also difficult to evaluate conclusively whether the Maintenance Plan's unique phased-segment approach has been successful in minimizing permanent negative impacts to habitat. Preliminary survey results suggest that CRLF have returned within a year to desilted areas that receive dry weather flows. In general, LLNL has found that the breeding ecology of the CRLF is strongly associated with open water pools (lentic), and slow moving flows (lotic). Prior to maintenance activities, several of the zones contained very dense stands of cattails that had virtually filled all open water habitat. Without trees or riparian canopy to provide shade, the cattails were the dominant form of vegetation in the ALP. The importance of cattails stands for the yearly CRLF cycle is unknown, but the open water pools are seemingly crucial for breeding. The 2003 breeding season should reveal important information on the impact of previously desilted zones on CRLF breeding.

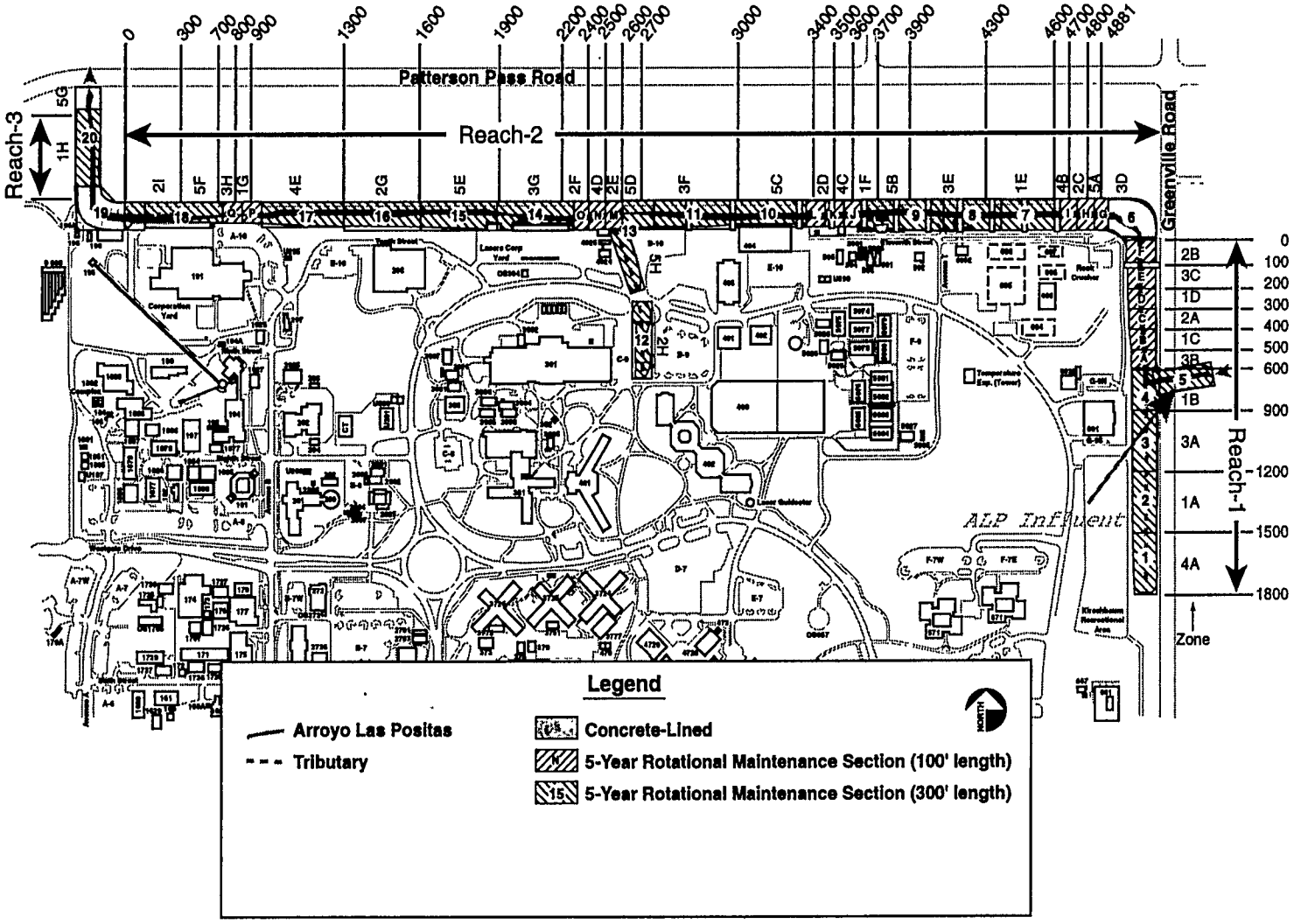

Figure 1. Arroyo Las Positas Maintenance Plan.

Table 1. Proposed seed mix of native plants.

Scientific name	Common name	Recommended seeding rate g/m^2 (lb/acre)
Polygonum punctatum	Knotweed, waterpepper	0.1 (1)
Juncus effusus	Soft rush	0.2 (2)
Juncus patens	Spreading rush	0.2 (2)
Eleocharis microphylla	Spike grass	0.28 (2.5)
Cyperus eragrostis	Nutsedge	0.4 (4)
Epilobium densiflorus	Dense spike-primrose	0.1 (1)
Pleuropogon californicus	Semaphore grass	0.4 (4)
Hordeum brachyantherum	Meadow barley	0.7 (6)
Rorippa nasturtium aquaticum	Watercress	0.17 (1.5)

Table 2. Turbidity and pH results for Segment 3E in 2000.

Date	Background	Receiving Water Concentration		
		Sample 1	Sample 2	Sample 3
Turbidity (mg/L)				
July 31	5.1			
August 24		42.3		
August 28		78.5	90.2	98.3
August 29		48.1	46.5	
August 30		41.9		
pH				
July 31	7.7			
August 24		7.8		
August 28		8.3	8.16	
August 29		8.05	7.92	

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This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.